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DUCTILE ORGANIC AEROGELS FOR MULTIFUNCTIONAL APPLICATIONS

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Monolithic polyurea aerogels were prepared by controlling the relative isocyanate/water/catalyst (Et₃N) ratio in acetone, acetonitrile, or DMSO to prevent precipitation, yielding polyurea (PUA) gels which can be subsequently dried to form highly porous (up to 98.6% v/v) aerogels over a very wide range of densities (0.016-0.55 g cm⁻³). The method has been implemented successfully with several aliphatic and aromatic di and triisocyanates. Polyurea aerogels were then studied at the molecular level, the elementary nanoparticle level, and the microscopic level. Their porous structure was probed with N₂-sorption porosimetry. Despite that the nanomorphology varies with density from fibrous at the low density end to particulate at the high density end, all samples consist of similarly sized primary particles assembled differently, probably via a reaction-limited cluster-cluster aggregation mechanism at the low density end, which changes into diffusion-limited aggregation as the isocyanate concentration increases. Higher density PUA aerogels (>0.05 g cm⁻³) are mechanically strong enough to tolerate the capillary forces of evaporating solvents and can be dried under ambient pressure; under compression, they can absorb mechanical energy (up to 90 J g⁻¹ at 0.55 g cm⁻³) at levels observed only with polyurea-cross-linked silica and vanadia aerogels (50-190 J g⁻¹ at similar densities). The airborne acoustic attenuation properties were found exceptional, and they do not follow mass law. These properties make the monolithic organic aerogels attractive multifunctional materials.